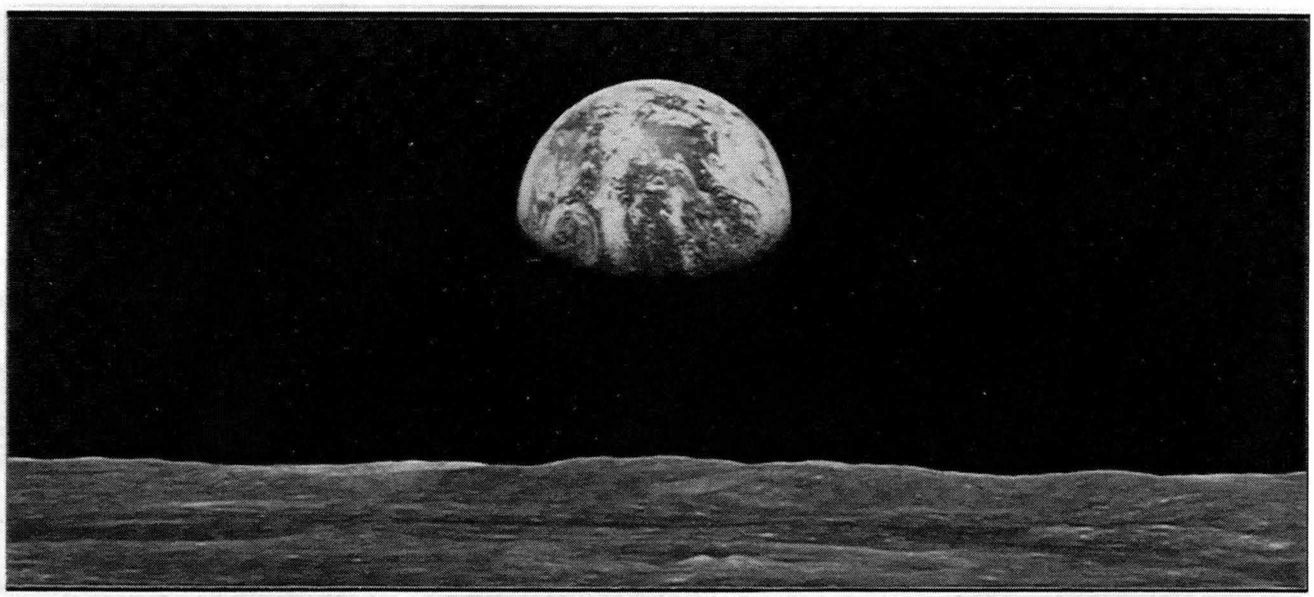
LUNAR *NEWS*

No. 55 July 1993



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Lunar News Mission

The purpose of "Lunar News" is to provide a newsletter forum for facts and opinions about lunar sample studies, lunar geoscience, and the significance of the Moon in solar system exploration.

Editor's Notes

"Lunar News" is published by the Office of the Curator, Solar System Exploration Division, Johnson Space Center of the National Aeronautics and Space Administration. It is sent free to all interested individuals. To be included on the mailing list, write to the address below. Your contributions to "Lunar News" on topics relating to the study of the Moon and comments about "Lunar News" and materials appearing here should be sent to the address below.

Curatorial Phone Numbers

Lunar Samples, Thin Sections, All Sample Requests
Jim Gooding .... (713) 483-3274
Bill Phinney .... (713) 483-5310
Antarctic Meteorites
Marilyn Lindstrom .... (713) 483-5135
Cosmic Dust and LDEF
Mike Zolensky .... (713) 483-5128
Educational Thin Sections
Jim Gooding .... (713) 483-5126
Loan Agreements and Records
Dale Browne .... (713) 483-5132
Technical Operations
Jim Townsend .... (713) 483-5331
Contamination Control
Dave Lindstrom .... (713) 483-5012

Mailing Address: SN2 Lunar Sample Curator, NASA
Johnson Space Center, Houston, Texas 77058-3696 USA

Electronic Mail:
Internet: gooding@sn.jsc.nasa.gov
NSI/DECNET: SN::GOODING

FAX: 713-483-2911

National Aeronautics and
Space Administration
Lyndon B. Johnson Space Center
Houston, Texas

The Patina Problem

By Paul Warren
University of California,
Los Angeles

Many lunar rock surfaces are covered by thin layers of darkened matter, or patina. The "space weathering" origin of these coatings is evident from their strong association with abundance of millimeter-scale impact craters ("microcraters" or "zap" pits).

The same space weathering process is probably mainly responsible for the darkness of lunar soils in comparison to fresh surfaces of typical lunar igneous rocks of similar composition. Of course, albedo of lunar rocks is a strong function of their predominant grain sizes, but even mare basalts with grains of the order of 1 mm across are much lighter than associated mare-dominated soils. The effect is magnified in the soils, because exposure ages of surfaces on small regolith particles are statistically greater than the typical or average exposure age of a lunar boulder surface (both types of fragment form by impact-shattering of bigger fragments; the smaller fragments are further removed from the target rock material). Similar weathering effects are evident from studies of "dark" chondritic meteorites.

As NASA plans future unmanned, non-sample-return missions to the Moon, asteroids, and other atmosphereless solar system bodies, the problem of widespread patina looms as a major impediment to geochemical/mineralogical analysis. Many such mission plans envisage spectrometric analyses using natural radiation (including light), measured from orbit. For the Moon, plans also

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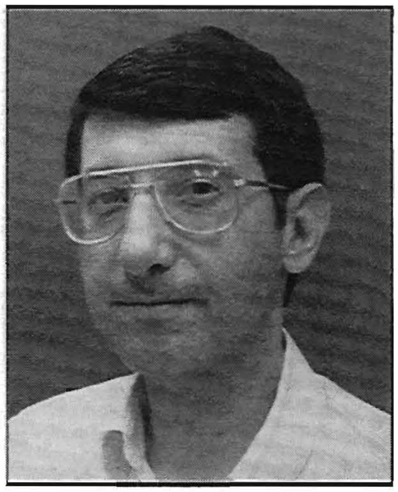

Curator's Comments

By Jim Gooding
NASA/JSC

LAPST Passes Advisory Baton to CAPTEM

Throughout its history, our program for curation and distribution of the Apollo lunar samples has benefited from advice provided by a panel of outside scientists with expertise in lunar science and the state-of-the-art analysis of geologic materials. During the days when the Apollo missions were being flown (1969-1972), the committee was named the Lunar Sample Analysis and Planning Team (LSAPT). LSAPT participated in the preliminary examination of the samples returned by each of the six lunar landing missions and made recommendations regarding all sample requests submitted by the international scientific community.

After the Apollo program ended, scientific interest in the lunar samples remained strong but the thrust they provided to planetary materials research led to an expanded interest in applying the lessons learned to more highly coordinated projects involving a consortium of specialists. In addition, the success of the robotic Viking landers on Mars (1976) created optimism that a Mars sample-return mission would follow and the expectation that handling of the Mars samples would require experience gained with the lunar samples. Accordingly, LSAPT evolved into the Lunar and Planetary Sample Team (LAPST). LAPST fulfilled the role of technical review of lunar sample requests, and the oversight of curatorial practices at Johnson Space Center, but also took the initiative to create and foster focused themes in lunar sample research. In addition, LAPST served as the principal advocacy group for planetary sample-return spaceflight missions. Special sample catalogs were published and many scientific workshops emphasizing lunar and planetary sample analysis were conceived and sponsored by LAPST. Through the 1970s and 1980s, many members of the planetary materials research community served one or more multiple-year terms on LAPST which, traditionally, emphasized participation by university scientists.

By the late 1980s, the Solar System Exploration Division at NASA Headquarters had commissioned a Science Working Group (SWG) for each of several different discrete areas of interest such as the Moon, Mars, minor planets, and outer planets. It seemed appropriate to include a SWG-level panel that would attend to issues involving planetary samples. Accordingly, LAPST retired when the Curation and Analysis Planning Team for Extraterrestrial Materials (CAPTEM) was chartered in 1993. CAPTEM will perform the same functions previously performed by LAPST but with greater emphasis on advocating the importance of sample collection and analysis as a vital part of planetary science. CAPTEM will report directly to the Chief of the Solar

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envisage rovers equiped with an "APX" (alpha-particle, proton, and X-ray) spectrometry system, for determining the composition of small areas of regolith and possibly surfaces of rocks. For some techniques such as gamma-ray spectrometry, patina would pose no problem (the gamma radiation source zone would be far thicker than any patina). But for most other envisaged analytical methods, the returned data would pertain to the outer few micrometers, if not the very surface, of the material. Obviously, every effort should be made to constrain the nature and effects of space weathering, especially the surface-compositional effects and the implications for spectrometric techniques.

The problem of lunar surface weathering was intensively studied in the 1970s, then largely ignored in the 1980s, but it appears that the 1990s will see a revival of interest. In the 1970s, a prevailing view was established that the "amorphous rims" on regolith particles form mainly as a result of bombardment by solar wind ions. Recent studies by Lindsay Keller and David McKay (NASA Johnson Space Center) have cast doubt on this interpretation. Keller and McKay have documented consistent enrichments in S and, to a lesser degree, Si in the amorphous rims. These enrichments are mirrored by depletions in Al, Ca, Ti and Mg. Keller and McKay argue that the rims are instead mainly products of recondensation of vapors produced during impacts. The darkening effect might be largely due to the presence of abundant submicroscopic iron-metal particles within the amorphous rims. Various studies in the 1980s showed that impact vaporization is capable of producing major, albeit localized,

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The Lunar Scout Program

By Don Morrison
NASA/JSC

***Editor's Note:** The Lunar Scout Program, along with the Mars Environmental Survey (MESUR) Pathfinder and Near Earth Asteroid Rendevous (NEAR) missions, was proposed in NASA's FY94 Technology Initiative budget. As of July 1, 1993, only MESUR Pathfinder has emerged from the budget process. The Technology Initiative was scaled down from approximately $500 million to $181 million—requiring the cancellation of some proposed new missions, including Lunar Scout. Unless some entirely unforseen event occurs, there is no possibility of a New Start in FY94 for Lunar Scout. Nonetheless, the Lunar Scout concept retains the scientific endorsement of the Lunar Exploration Science Working Group (LExSWG), the Curation and Analysis Planning Team for Extraterrestrial Materials (CAPTEM), and other planetary science advisory groups.*

Since the end of the Apollo program in 1972, lunar scientists have advocated global geochemical and mineralogical mapping of the entire lunar surface using a dedicated lunar-orbital spacecraft. Although various concepts for such a mission never reached fruition, continuing interest in further exploration of the Moon led to an economical but scientifically rich mission concept known as the Lunar Scout Program.

The Lunar Scout program consists of two launches involving two spacecraft equipped to produce comprehensive chemical, mineral-

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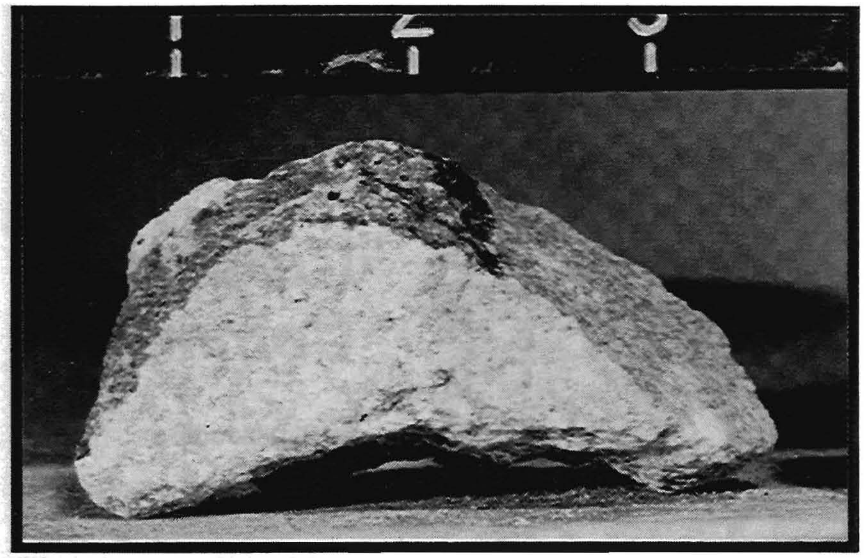

Effects of space weathering are starkly illustrated by this Apollo 17 rock 76239. Most of this rock's surface is relatively fresh, and thus light-colored with few microcraters. In contrast, the surface in the upper left has endured a long exposure at the surface of the Moon, which has left it darkened, and densely pocked with microcraters. NASA photo S-73-16712.

The Patina Problem
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geochemical fractionation effects at the surface of the Moon. Recent studies of chondritic meteorites (e.g., by Dan Britt, University of Arizona) have likewise pointed toward submicroscopic opaques, especially iron-metal particles, as the proximal cause of the darkening effect. The issue is far from final resolution, however. The solar wind is probably S-rich compared to lunar materials, and the French researchers who originally developed the solar wind damage model (M. Maurette and coworkers) pointed out that they find amorphous rims on 90% of the small silicate grains in mature soil, yet on none of the ilmenite grains. Such a mineralogical effect is hard to reconcile with a vapor condensate model. On the other hand, Keller and McKay point to their discovery of a cristobalite (SiO_2) grain with a basaltic amorphous rim, which could hardly have formed by solar wind ion damage.

Perhaps both models are partly correct. In any event, a better understanding of the patina question will greatly aid in the interpretation of future planetary mission data. For example, if the vapor condensate model is correct, the surfaces analyzed will generally be quite different from the crystalline matter beneath. Aided by recent major advances in surface-analysis technology, future studies of Apollo samples should provide a much clearer picture of the mechanisms by which space weathering alters rock surfaces.

The Apollo Lunar Surface Journal

By Eric M. Jones
Los Alamos National Laboratory, New Mexico

During the six successful lunar landing missions, the Apollo crews accumulated about 24 man-days of experience living and working on the Moon. The Apollo Lunar Surface Journal is an annotated transcript of the Air-to-Ground communications recorded during the lunar surface operations; and it is intended to make the details of the Apollo experience accessible to the generation of engineers, scientists, and astronauts who, sooner or later, will design, build, and operate the permanent Lunar Base. The Journal is being prepared with the help of most of the Apollo astronauts who spent time on the Moon.

The Journal is intended as a contemporary counterpart of such notable exploration journals as those of Captain James Cook and the great Norwegian explorer, Roald Amundsen. Amundsen, for example, took an approach to exploration very similar to the one taken years later by the Apollo team. He understood the value of careful planning and was a veteran of years of work in the Arctic before he attempted his trip to the South pole. When he finally decided to go the the Antarctic, he was better prepared than anyone who had ever been there before; and, yet, one element of his preparation was to read and re-read the accounts of prior expeditions, always on the lookout for detail and nuance, the little lessons that would make his expedition a little more trouble-free. He even took his small library of journals with him to the Bay of Whales and, after a season of laying caches along his planned route to the Pole, spent the following winter at his base camp, working and reworking his equipment and procedures and reading the old journals again and again.

When we return to the Moon, we will be able to build on the wealth of experience accumulated during Apollo. One of the basic repositories of that experience—particularly with regard to the lunar work experience—is the collection of Air-to-Ground transcripts prepared during the missions by the NASA Public Affairs Office. The transcripts contain a level of detail unmatched in the history of exploration; and all that is really needed to make them accessible to people who weren't intimately involved in Apollo is some translation of the verbal shorthand and some explanation of the technical detail.

Work on the Journal began in April 1989. From time to time during the last four years, I met with one or both members of a lunar surface crew and, with them, did minute-by- minute reviews of the missions. We used copies of the raw transcripts, copies of the original audio and video tapes, and such essential background material as the Mission Reports, the

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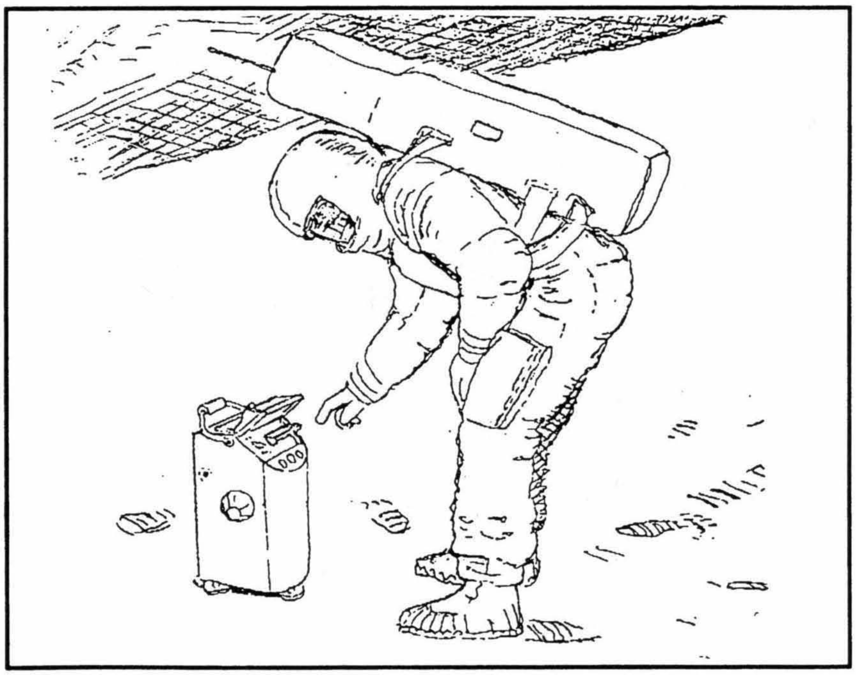

A pre-mission artist's concept of how to deploy the Apollo Traverse Gravimeter on the Moon. In some ways, this picture is hilarious, when compared with actual accounts in "The Apollo Lunar Surface Journal" by Eric Jones. Because of the weight of the backpack, Gene Cernan (who operated the TGE on Apollo 17) would have pitched forward. Also, the waist joint wouldn't have flexed this much with the suit inflated. In reality, Gene would have stood with the gravimeter at his side and then, flexing his knees and keeping the backpack over his feet, would have done a little knee bend to punch the button.

The Apollo Lunar Surface Journal
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Technical Debriefs, the Lunar Rover Handbook, and Judy Allton's recent Apollo Tool and Container Catalog. The basic idea was to create enough commentary that an uninitiated reader could understand exactly what was going on and why. During each of the reviews, we listened to the audio tapes—or, when appropriate, watched the video tapes—and followed along in the raw transcripts, correcting the occasional errors as we went. Whenever I didn't understand something or one of us thought there was a point that needed to be made, we stopped the playback, turned on a separate tape recorder, and talked about the subject at hand. Generally, the astronauts found it easy to "get back into the mission" and, for many of them, it was the first time since the post-flight debriefings that they had encountered a chance to think about the experience in such detail. We started the reviews at the point in the mission when the Lunar Module (LM) engines were fired for the descent to the surface and ended when the crew was safely back in lunar orbit. Typically, a review of one of the three-day lunar visits would take from ten to twelve days with most of the time taken up by the EVAs. Generally, we concentrated on the work experience, talked about what was easy about the work and what was hard, how the training and the experience of prior crews had helped increase productivity from mission to mission, and about the little tricks that they devised to overcome the limitations of the suits and to take advantage of the weak gravitational field.

To date, reviews have been completed with eight of the twelve astronauts who have been on the Moon. The commentary for Apollos 11, 12, and 17 has been transcribed and edited; and, indeed, the complete Apollo 17 manuscript is now in the hands of the crew for final review. I wish I could report that publishers were fighting over rights to the Journal. However, because of the size of the project—2400 pages of text and 800 pages of photographs, maps and equipment drawings—and the limited market for so large a work, the lack of interest on the part of publishers is understandable. What seems most likely at present is that, initially, I will get the edited text out to the community on CD-ROM format and, at a later date, add the illustrations. If all goes well with the final editing, the Apollo 17 manuscript should be ready for release by the end of 1993.

Work on the Apollo Lunar Surface Journal has been supported by the Los Alamos National Laboratory.

Apollo 17 Astronaut Jack Schmitt at Camelot Crater, taken as part of Station 5 at the end of EVA 2. Jack is using the extension handle as a measuring rod to help get good focus for a cross-Sun photo of the large boulder in the foreground. The object on the rock is a gnomon with a color/gray scale on the east-pointing leg. The South Massif is in the background. Note also the sample collection bag on Jack's Portable Life Support System (PLSS). His boots are probably very dirty at this stage of the mission. (NASA photo AS17-145-22157)

The following is an excerpt from the Apollo 17 Lunar Surface Journal taken from an early stage in second EVA. Cernan and Schmitt are on the Rover and are driving west from the LM toward Camelot Crater. At the start of the drive, they stopped at the SEP (Surface Electrical Properties experiment) transmitter and initialized the Rover navigation unit. Since then, they have driven about 500 meters to a place where they will deploy a small seismic charge. The Capcom is Astronaut Robert Parker. The commentary recorded during the mission reviews is set off in square brackets. Minor editorial remarks are indicated by parenthesis. Three ellipses (...) are used to indicate an interrupted thought or overlapping conversation.

Cernan: (To Jack) How are we doing (on the distance from the SEP)?
Schmitt: (0.)5 (kilometers).
Cernan: (To Parker) Okay, Bob. Here's your charge (location). Pick a spot, Jack.
Schmitt: Okay; can you swing right over there . . .
Cernan: Yeah.
Schmitt: . . .about 10 meters ahead?
Cernan: Okay.
Schmitt: Give me a shallow turn. (Pause)
Cernan: How's that?
Schmitt: Okay. And I'll set it right there in that. . .Can you move forward, and I'll get it in that little depression.
Cernan: Okay.
Schmitt: You see on the other side of the rock.
Cernan: Yeah. (pause) Okay, Bob; 083, 0.6, and 0.5. *[Gene is giving Parker the bearing to the SEP transmitter (83 degrees east of north), the distance driven (0.6 kilometers), and the range (0.5 kilometers). Because they have been weaving a bit to get around small craters, the straightline distance is probably about 540 meters].*
Schmitt: Okay. (Pulling the three arming pins). Pin 1, pulled and safe. Pin 2, pulled and safe. Pin 3 pulled and safe. (To Gene) Ever stop and ask yourself what I'm doing (pulling pins on an explosives charge)?
Parker: (Acknowledging that the pins are pulled and safe) I copy that, Jack. . .
Cernan: (Responding to Jack's question) Yes. (Laughter) *[Schmitt - "The seismic charges had an Apollo Standard Initiator (ASI) which was the pyrotechnic initiator they used for everything - for any kind of explosive bolt initiation, for instance. It was hooked up to a radio receiver and, at 90 hours after I pulled the pins, a timer moved a metal window from between the initiator and the charge and for half an hour the ground could send a signal to set off the initiator and, therefore, the charge. If it hadn't gone off in the half hour, then the window would close again and that would be the end of it. All of them actually did go off but, if they hadn't, they would have been safe sitting up there when the people from the Smithsonian went to collect them sometime in the future."]*
Parker: (Continuing under the banter about the charge) . . . If you can give us a frame count, we'd appreciate it. And I might remind you to both check that . . .
Cernan: (To Jack) Don't fall over!
Parker: . . . you're at Min cooling since you've got a long drive ahead of you there. *[Cernan - "Jack had to lean over to get the charge on the ground. Of course, we were riding low to the ground, but he had to reach to get the charge outside the fenders. He probably grabbed the antenna on the charge to set it down. Then, when we started up again, I had to be careful not to run into the charge and knock it over. With the front-and-rear, Ackermen steering, if you turned left away from the charge, rather than the rear wheels dragging, the rear wheels were going to turn right and maybe hit the charge; so I had to turn right to avoid it."]*
Schmitt: Hey, I lost my sample thing. *[Apparently, the head of a tool called the Lunar Rover Sampler has come off its handle. They'd had trouble getting it on during the geo-prep at the ALSEP site.]*
Cernan: (Garbled) on the floor.
Schmitt: I hope so. (pause) *[Because of the stiffness of the suit and the bulk of the chest-mounted RCU (Remote Control Unit) and camera blocking his view of his feet, Jack has no chance of looking for the sampler without getting off the Rover. Gene can see parts of Jack's foot pan, but not all of it.]*
Cernan: (Asking about the charge placement) That look good?
Schmitt: Yeah, it's going to stay.
Cernan: Okay. Have you got anything (garbled). If not, I'll do a partial (photographic) pan for you. *[Gene is suggesting that he turn the rover in a slow circle so that Jack can take a sequence of photos for a partial pan to document the charge location. This technique was invented by young and Duke during their second Apollo 16 EVA.]*
Schmitt: Yeah. We got to do a partial. I'd like to know where that sampler is. Well, we can do without it, I guess.
Cernan: Well, it's sure nice to . . . What did it do, come off the end?
Schmitt: Yeah, I think I can check it, though.
Cernan: Getting your (photographic) pan?
Schmitt: Yeah. If you go around to seeing that big block there by the ALSEP, then you can forget it. *[Jack is telling Gene that, once they are pointed at Geophone Rock, they will have finished the partial pan.]*
Cernan: Okay. Okay. I'll just come around, and I'll pick up my tracks. do you want to get that sampler? Can you see it?
Schmitt: I think I'd better look.
Cernan: All right. Take a look. (To Parker, while Jack dismounts) Bob, one stop here for about 2 seconds.
Parker: Okay, copy that.
Schmitt: Okay, it's down here.

The Lunar Scout Program
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	Data Returned	Coverage
Lunar Scout I		
X-Ray Spectrometer	Major elements	Global
Neutron Spectrometer	H and other volatiles	Global
High-Resolution Stereo Camera	Imaging/Topography	Global/Regional
Lunar Scout II		
Ge Gamma-Ray Spectrometer	Major and minor elements	Global
Imaging Spectrometer	Minerals at 0.35 - 2.4μm	Global/Regional
Lunar Scout I and II		
Gravity	Global gravity	Global

ogical, and imagery maps of the entire lunar globe, and probe the structure of the lunar crust and interior by refining the lunar gravity model, capitalizing on the investment made in the past two decades in lunar sample research and lunar science. This opportunity to tie extensive ground truth to a global view distinguished the Scout missions and their lunar orbit science from other planetary science missions. The instruments that comprise each spacecraft are shown in the table above.

The gravity experiment utilizes dual doppler tracking of Lunar Scout I at an altitude of 100 km using Lunar Scout II as a relay to capture backside data.

In addition to the instruments listed in the table, negotiations with the Ballistic Missile Defense Office (formerly known as the Strategic Defense Initiative Office) are essentially complete for flying the "Clementine" laser altimeter on Lunar Scout I at no cost to NASA for the instrument.

Cost of each launch was capped at $145 million including launch vehicle, spacecraft, instruments, mission integration, operating costs for one year, and data reduction. Total program costs are estimated as $290 million (inflation corrected) for launches in 1996 and 1997.

The instrument complement includes some technical advances after the following opportunities:

1. First flight in interplanetary space of a Ge detector equipped gamma-ray spectrometer actively cooled by mechanical pumps to its optimum operating temperature of 80K and capable of operating at the Moon for more than one year.

2. The first flight of a true imaging spectrometer with a spectral range of 0.35 to 2.4μm, 192 spectral channels and 256 spatial channels for global coverage of mineralogy.

3. An X-ray spectrometer with an expanded spectral range capable of measuring the major rock-forming elements globally with a footprint as small as ten km.

4. A high-resolution stereo camera with three axes (three focal plate modules of three CCD lines each rather than two sets of CCDs) for global and regional stereo imagery and geodesy. (This camera will map Mars during the Russian Mars 94 mission.)

5. A neutron spectrometer with detectors for epithermal, thermal and fast neutrons, and capable of mapping H abundances at the 100 ppm level or better.

A two-step global mapping strategy is key to the mission. Global data is acquired first by orbiting the Moon at a relatively high altitude (300 km for Lunar Scout I and 500 km for Lunar Scout II) determined by a variety of instrument, data storage, and data rate constraints. Later, regional data is obtained by descending to a lower altitude of 100 km (a balance between proximity to the lunar surface and fuel requirements for orbital maintenance). All data are acquired in polar orbits. The global data sets could have been obtained in one month because of the capabilities of the instruments and Deep Space Network (DSN) downlink capacity that will be on line in 1995. A backup mode consists of orbiting for more than one month at the higher altitudes if contingencies arise.

The strategy produces nested and complementary global data sets supplemented by high resolution regional data for stereo imagery

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The Lunar Scout Program continued from page 8

and mineralogy. Global chemistry is obtained by the gamma-ray, neutron and x-ray spectrometers. The gamma-ray spectrometer can measure the abundances of the major rock-forming elements, minor elements, K, U and Th, and the rare earths Sm and Gd with a footprint on the order of 100 km. On the same 100 km spatial scale, the neutron spectrometer can measure the abundance of H, and by inference other volatiles, at the 100 ppm level to a depth of 150 g/cm^2, or about 60 cm in typical regolith. In addition, the derived neutron spectra can significantly enhance the precision of the gamma-ray data. This complete chemical and volatile characterization is averaged over sizable terrain blocks, too large for discriminating detailed crustal stratigraphy. The x-ray spectrometer can provide the higher resolution view by measuring Si, Mg, Al, Ca, Fe and Ti with footprints on the order of 10-30 km, which is critical for detailed characterization of the stratigraphy of the crust. The nested gamma-ray and x-ray data can provide a powerful tool for constructing a geochemical map, a tool made more powerful through correlation with mineralogical data.

Global mineralogy at 200 meters per pixel for 78% of the Moon and at 400 meters per pixel for the 22% remaining on the farside can be achieved with the imaging spectrometer devised by Brown University, SETS Technology and Ball Aerospace. Regional mapping of mineralogy at 80 meters per pixel is acquired for up to 10% of the Moon during the lower altitude regional mapping phase. Mineralogical maps can be accurately related to the landforms or geological units that they represent because the landforms are actually imaged by the imaging spectrometer. Correlating mineralogy with the geochemistry can result in a detailed global geologic map.

Stereo imagery and an accurate geodetic map that ties all points on a globe together to an accurate grid is an essential element of a global map. The High Resolution Stereo Camera can produce global stereo imagery at 24 m for the entire Moon from an altitude of 300 km in one month of mapping at Sun angles optimized for photogeology and photogrammetry. High resolution stereo imagery at a resolution of 4 m per pixel resolution is obtained by the stereo camera at 100 km orbital altitude. Up to 26% of the lunar surface could be covered at this resolution during the course of regional mapping sequence at 100 km altitude. Topography and geodesy can be derived photogrammetrically from the stereo data and correlated with the gravity measurements. Global topography with better than 50 m contour intervals can be constructed and digital terrain models computed. Local topography with contour intervals on the order of 10 meters or less can be produced from the regional stereo imagery. A global geodetic net with latitude and longitude accuracies of approximately 100 meters and an absolute elevation accuracy of between 20 and 50 meters could be achieved.

The gravity field can be measured to the sub-5 mgal (1 mgal = 10^{-5} m/s^2) level, providing a look into the structure of the crust and upper mantle. Coverage of the gravity would be global because of the use of one Scout as a relay as measurements were made by the other at an altitude of 100 km.

The Lunar Scout Program demonstrates some useful alternatives to the traditional methods of putting together a planetary science mission. Either the Lunar Scout Program, or an equivalent lunar polar orbiting mission, should be placed into the planetary science queue at some time in the future.

Apollo 17 Catalog at Halfway Mark

As announced in *Lunar News* No. 54 (January 1993), the *Catalog of Apollo 17 Rocks* is being published as four volumes (JSC Pub. No. 26088) comprising more than 2000 pages of photographs, data tables and charts, and narrative descriptions. Volumes 1 and 2 were published and distributed on schedule in February 1993. Volumes 3 and 4 have fallen behind schedule as the authors and graphic artists continue the mammoth task of compiling the data and placing it in publishable format. We now expect that Volume 3 will be printed in August 1993 and Volume 4 likewise by November 1993. Therefore, if you requested a four-volume set, you should have received only the first two volumes so far. The final two volumes should be on your bookshelf before the end of 1993.

Curator's Comments
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System Exploration Division at NASA Headquarters. As before, the Curator will work closely with CAPTEM to assure the best possible handling of the lunar samples as well as prudent planning for curation of future sample collections whether they come from Mars, asteroids, comets, or other sources.

The first CAPTEM meeting was held at the Lunar and Planetary Institute in Houston on June 2-3, 1993, and was attended by seven regular members, three ex-officio members, and invited observers. Lunar sample requests, involving more than 400 samples, were recommended for 14 different investigators who had submitted requests since the last LAPST meeting in February 1993. In addition, plans were discussed for future CAPTEM initiatives and workshops. CAPTEM reviewed and endorsed the Lunar Scout mission concept which is described elsewhere in this newsletter. Future meetings will be held on centers of three to four months with the next meeting occurring in late September 1993.

Samples of Lunar Core 68002 Now Available

By Carol Schwarz
Lockheed Engineering and Science Company

Two dissection passes of 68002, the top section of Apollo 16 double drive tube 68002/68001, have been completed. The core was dissected in 0.5 cm depth increments along two 1-cm-thick longitudinal layers (passes) starting at the lunar surface and continuing through the length (26.7 cm) of the core. The third pass has yet to be completed. Soil from each increment of the first pass was separated into coarse and fine fractions using a 1-mm sieve. The coarse particles were examined and photo-documented. Samples from these two passes are available for study.

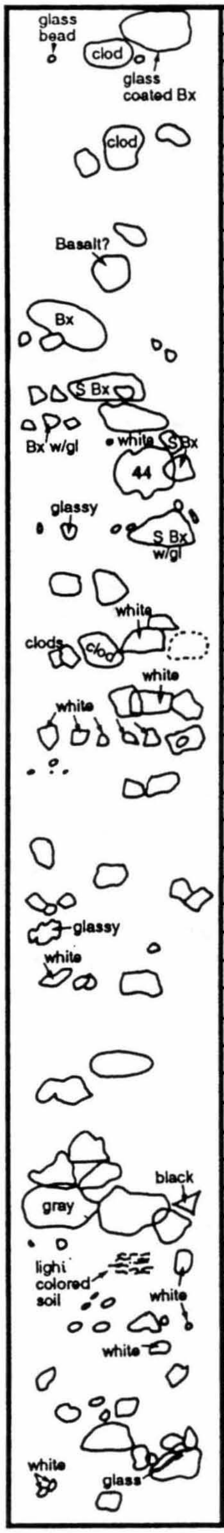
68002 was extruded from the drive tube on February 17, 1993. The color was determined to be 10YR 5/1 on the Munsell color scale and no distinct color boundaries were observed during dissection. A void was present from the lunar surface to about 3.5 cm. The top 4 cm was loose and below that the soil was noticeably more coherent. Friable soil clods were abundant from 9.5 to 14.5 cm from the lunar surface.

A close examination of particles >1 mm from the first dissection pass showed that about 84% (by number) of the particles are in the 1-2 mm size range, 15% were 2-4 mm, 1% were 4-10 mm, and less that 1% were >10 mm.

Lithology of the >1 mm fraction was determined by binocular microscopic examination of the particles from the first pass and is summarized as follows: 57% are various types of breccias, 15% are glasses including glass shards, agglutinates, and glass-coated breccias, 14% are dark, coherent, and often dusty, 12.5% are white or light gray (anorthositic), and about 1.5% are basalts. Sub-sample ,44 (1.395 g), a dusty, possibly metallic, irregular-shaped piece, was extracted from the 7.7-8.5 cm interval. A large anorthositic fragment, located at 0.4-3.4 cm from the lunar surface was uncovered and will be extracted and numbered after completion of the third pass.

The diagram for the first dissection pass follows and identifies sample splits which are available for allocation. Samples have been allocated to Dr. Richard Morris at NASA/JSC who will measure soil-maturity indices by ferromagnetic resonance. His results are expected to be available for our next newsletter issue (January 1994).

DRIVE TUBE 68002 (First Pass)



Depth (cm)	<1 mm Fraction Sample No.	<1 mm Fraction Sample Wt.	>1 mm Fraction Sample No.	>1 mm Fraction Sample Wt.	Special Samples No.	Special Samples Wt.	Special Samples Type
0.5	10	.771	11	.150			
1.0	12	.545	13	.024			
1.5	14	.675	15	.018			
2.0	16	.806	17	.061			
2.5	18	.773	19	.055			
3.0	20	.967	21	.110			
3.5	22	1.051	23	.096			
4.0	24	.995	25	.081			
4.5	26	1.492	27	.108			
5.0	28	1.354	29	.154			
5.5	30	1.777	31	.126			
6.0	32	1.603	33	.583			
6.5	34	1.507	35	.192			
7.0	36	1.327	37	.521			
7.5	38	1.424	39	.805			
8.0	40	1.133	41	.172	44	1.395	cp w/metal?
8.5	42	1.411	43	.227			
9.0	45	1.712	46	.144			
9.5	47	1.540	48	.343			
10.0	49	1.671	50	.193			
10.5	51	1.843	52	.193			
11.0	53	1.473	54	.113			
11.5	55	1.690	56	.532			
12.0	57	1.932	58	.399			
12.5	59	1.803	60	.456			
13.0	61	1.930	62	.350			
13.5	63	2.085	64	.175			
14.0	65	1.686	66	.288			
14.5	67	1.944	68	.165			
15.0	69	2.216	70	.278			
15.5	71	1.967	72	.183			
16.0	73	2.178	74	.263			
16.5	75	1.878	76	.190			
17.0	77	1.874	78	.126			
17.5	79	1.902	80	.219			
18.0	81	2.051	82	.121			
18.5	83	1.831	84	.124			
19.0	85	2.042	86	.295			
19.5	87	2.218	88	.229			
20.0	89	2.130	90	.197			
20.5	91	1.990	92	.174			
21.0	93	1.832	94	.225			
21.5	95	1.997	96	.694			
22.0	97	1.723	98	.168			
22.5	99	2.116	100	.449			
23.0	101	2.243	102	.119			
23.5	103	2.041	104	.247			
24.0	105	2.130	106	.172			
24.5	107	1.512	108	.184			
25.0	109	2.030	110	.394			
25.5	111	1.960	112	.295			
26.0	113	1.893	114	.320			
26.5	115	2.047	116	.255			
26.7	117	1.136	118	.099			

How to Request Lunar Samples

NASA policies define lunar samples as a limited national resource and future heritage and require that samples be released only for approved applications in research, education, and public display. To meet that responsibility, NASA carefully screens all sample requests with most of the review processes being focused at the Johnson Space Center (JSC). Any and all individuals requesting a lunar sample should follow the steps given below for the appropriate category of sample.

1. RESEARCH SAMPLES (including thin sections)

NASA provides lunar rock, soil, and regolith-core samples for both destructive and non-destructive analysis in pursuit of new scientific knowledge. Requests are considered for both basic studies in planetary science and applied studies in lunar materials beneficiation and resource utilization.

A. The sample investigator demonstrates favorable scientific peer review of the proposed work involving lunar samples. The required peer review can be demonstrated in any one of three ways: (1) A formal research proposal recommended by the Lunar and Planetary Geosciences Review Panel (LPGRP) within the past three years; (2) A formal research proposal recommended by the Indigenous Space Resources Utilization (ISRU) panel for work pertaining to the specific sample request (step B); (3) Submittal of reprints of scientific articles pertaining directly to the specific sample (step B) and published in peer-reviewed professional journals.

B. The investigator submits a written request specifying the numbers, types, and quantities of lunar samples needed as well as the planned use of the samples. For planetary science studies, the sample request should be submitted directly to the Lunar Sample Curator at the following address:

Dr. James L. Gooding
Lunar Sample Curator
SN2
NASA/Johnson Space Center
Houston, TX 77058-3696
USA
Fax: (713) 483-2911.

For engineering and resource-utilization studies, the sample request should be submitted to the Lunar Simulant Curator at the following address:

Dr. Douglas W. Ming
Lunar Simulant Curator
SN4
NASA/Johnson Space Center
Houston, TX 77058-3696
USA
Fax: (713) 483-5347.

The Lunar Simulant Curator will arrange for an ISRU review of the applications-oriented sample request to assure that all necessary demonstration tests with simulated lunar materials have been satisfactorily completed. Requests determined to be sufficiently mature to warrant consideration for use of lunar materials will then be forwarded to the Lunar Sample Curator.

For new investigators, tangible evidence of favorable peer review (step A) should be attached to the sample request.

Investigators proposing the application of new analytical methodologies (not previously applied to lunar samples) also should submit test data obtained for simulated lunar materials. New investigators who are not familiar with lunar materials should consult *Lunar Sourcebook: A User's Guide to the Moon* (G. Heiken, D. Vaniman, and B. M. French, Eds.; Cambridge University Press, 736 pp.; 1991; ISBN 0-521-33444-6) as the best available reference on the chemical and physical properties of lunar materials.

C. The Lunar Sample Curator will research the availability of the requested samples and decide whether a unilateral action can be taken or an outside scientific review is required. Outside review is prescribed for all new investigators and for most established investigators except where returned (previously used) samples are being requested. For outside review, the Curator forwards the original request, with background information, to the Curation and Analysis Planning Team for Extraterrestrial Materials (CAPTEM), a standing committee of scientists who advise NASA on the care and use of lunar samples. CAPTEM checks for favorable peer review (step A) and appropriate sample selection (step B).

D. Given CAPTEM endorsement and concurrence by NASA Headquarters, the Lunar Sample Curator will prepare a Lunar Sample Loan Agreement for signature by the investigator's institution. The agreement includes a simple security plan that prescribes precautions to minimize prospects for theft or unauthorized use of lunar samples.

E. Upon receipt of the properly executed loan agreement, the Lunar Sample Curator prepares the authorized samples and sends them to the investigator. Quantities less than 10 grams can be sent directly by U. S. registered mail to domestic investigators. Shipments to foreign investigators are sent by U. S. diplomatic pouch mail to the American embassy nearest the requestor's location. Quantities larger than 10 grams must be hand-carried by the investigator or his/her representative.

F. Continuation as a Lunar Sample Investigator. An investigator's privilige for retention and use of lunar samples is contingent upon continued good standing with the Office of the Curator. The investigator will remain in good standing by fulfilling the following obligations: (1) Maintenance of, and adherence to, the lunar sample loan agreement and security plan; (2) Timely cooperation with annual lunar sample inventory; (3) Timely cooperation with sample recalls.

2. PUBLIC DISPLAY SAMPLES

NASA provides for a limited number of rock samples to be used for both short-term and long-term display at museums, planetariums, expositions, or professional events that are open to the public. Requests for such display samples are administratively handled by the JSC Public Affairs Office (PAO). Requestors located in the United States should apply in writing to the following address:

Mr. Boyd E. Mounce
Lunar Sample Specialist
AP4/Public Services Branch
NASA/Johnson Space Center
Houston, TX 77058-3696
Fax: (713) 483-4876.

Requestors in foreign countries must contact the public affairs officer of the United States Information Service (USIS) at the nearest American embassy. The USIS will contact Mr. Mounce to determine whether the loan of a display sample is appropriate.

For both domestic and foreign requestors, Mr. Mounce will advise successful applicants regarding provisions for receipt, display, and return of the samples. All loans will be preceded by a signed loan agreement executed between NASA and the requestor's organization. Mr. Mounce will coordinate the preparation of new display samples with the Lunar Sample Curator.

3. EDUCATIONAL SAMPLES
(disks and educational thin sections)

A. Disks

Small samples of representative lunar rocks and soils, embedded in rugged acrylic disks suitable for classroom use, are made available for short-term loan to qualified school teachers. Each teacher must become a certified user of the disks through a brief training program prior to receiving a disk. Educational sample disks are distributed on a regional basis from NASA field centers located across the United States. For further details, prospective requestors should contact the public affairs office at the nearest NASA facility or write to the following address:

Mr. Larry B. Bilbrough
FEE/Elementary and
Secondary Education
NASA Headquarters
Washington, DC 20546.
Fax: 202-358-3048

B. Thin Sections

NASA prepared thin sections of representative lunar rocks on rectangular 1 x 2-inch glass slides, with special safety frames, that are suitable for use in college and university courses in petrology and microscopic petrography for advanced geology students. Each set of 12 slides is accompanied by a sample disk (described above) and teaching materials. The typical loan period is two weeks, including round-trip shipping time. Each requestor must apply in writing, on college or university letterhead, to the following address:

Lunar Sample Curator
SN2
NASA/Johnson Space Center
Houston, TX 77058-3696.

For each approved user, the Curator will prepare a loan agreement to be executed between NASA and the requestor's institution prior to shipment of the thin-section package.

Accessing the JSC SN2 Curatorial Data Bases

The Office of the Curator maintains publicly available, dial-up electronic data bases of inventory information for lunar samples as well as for other sample collections in our care. The data bases are built upon the processing and allocation histories of samples, rather than on compositional data, but can be used advantageously by investigators who are researching the availability or parentage of specific samples. The curatorial data bases can be accessed as follows:

Via DECNET	1) Log onto your host computer. 2) Type **SET HOST 9300** at the system prompt. 3) Type **PMPUBLIC** at the USERNAME: prompt. NOTE: Your system manager may add node CURATE to the DECNET data base on your host computer; the SPAN node number is 9.84. You may then access CURATE by typing **SET HOST CURATE** instead of **SET HOST 9300.**
Via INTERNET	1) Type **TELNET 146.154.11.35** or **TELNET CURATE.JSC.NASA.GOV.** 2) Type **PMPUBLIC** at the USERNAME: prompt.
Via modem	The modem may be 300, 1200, or 2400 baud; no parity; 8 data bits; and 1 stop bit. If you are calling long distance, the area code is 713. 1) Dial 483-2500. 2) Type **SN_VAX** in response to the Enter Number: prompt. 3) Hit <CR> 2 or 3 times after the CALL COMPLETE message. 4) Type **J31X** in response to the # prompt. 5) Type **PUBLIC** in response to the Enter Username> prompt. 6) Type **C CURATE** in response to the Xyplex> prompt. 7) Type **PMPUBLIC** at the USERNAME: prompt.

For problems or additional information, you may contact:

Claire Dardano
Lockheed Engineering & Sciences Company
(713) 483-5329